Experimental Investigation On Edm For Ss 307 Material To Improve Geometrical Error Using 3d Shaped Copper Electrode

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ABSTRACT
A comprehensive investigation made on Electrical Discharge Machining (EDM) parameters for improving geometrical error on complex shapes. This article includes research of various parameters like metal removal rate, tool wear rate and angularity which is essential for achieving geometrical tolerance. Complex shaped 3d copper electrode is used for machining of SS 307 steel material since copper has high electrical conductivity. Taguchi's orthogonal array analysis is adopted to find the input sparking parameters combinations like pulse on time, pulse off time, current and dielectric pressure. Experimental results shown in MWR, TWR and geometrical error were improved which can be optimized by use of EDM process.

Keyword: EDM; MRR; TWR; Parallelism.

1.0 INTRODUCTION
SS 307 steel material is well-recognized as promising engineering material for their high performance and excellent properties such as high tensile strength, with a combination of good ductility and shock resistances 307, is used for engineering structural, machine tool and railway linear, marine shaft building, and a wide variety of applications where a good quality high tensile steel is required. It is possible to machine the material extremely accurately by use EDM.

Over a number of years spark EDM developed volume over MRR, enhanced surface roughness, and less electrode wear. Usually, EDM is used to machine any electrically conductive components with less wear rate MRR. Solid electrode is used in the machining of SS 307 steel material to increase MRR in the EDM process. Furthermore, the EDM of SS 307 steel, with solid tool copper electrode, was employed to improve the MRR and decrease the tool wear rate and surface roughness, which is mostly affected by current, pulse on time, and spark gap set voltage. To improve MRR and decrease tool wear as an...
attempt to find the most suitable electrode material, Cu, Cu-W and Ag-W materials are used for EDM which suggest, Cu electrode as having the highest MRR, followed by Cu-W and Ag-W electrode, it is also suggested that copper electrode are suitable for achieving a high metal removal rate pertaining to the electrical discharge while machining SS 307 steel.

1.2. LITREATURE REVIEW

Ko-Ta chiang (2007) [1] - This research includes study on material removal rate, tool wear electrode on POWDER MIXED ELECTRICAL DISCHARGE MACHINING (PMEDM). Electrical Discharge Method for removal of material having higher grade of hardness. The effect of powder mixed into the dielectric fluid of EDM was initially studied and it is proposed that the machining rate increased with increase of the powder concentration. Processing parameters include machining time, current, pulse on time, pulse off time, grain size and concentration of aluminum powder particle for machinability of MRR and TWR. Akhil Sharma (2007) [2] – Electrical discharge machining to find material removal rate (MRR), tool wear rate (TWR) on Al-4Cu-6Si steel. The EDM of Al-4Cu-6Si steel-10%wt. % SiCp composites was made using 30mm brass electrode and the effect of pulse current, gap voltage and pulse duration on the metal removal rate (MRR), tool wear rate (TWR) and radial over cut (ROC) were studied using Design of Experiment (DOE) technique. Takayuki TANI (2009) [4] - Insulating ceramic material were processed with sinking and wire cut electrical discharge machining method. In this Assisting Electrode Method (AEM), new machining method is used as insulating material by EDM and was processed. An electrical conductive thin layer was boned on the work piece used in the discharge process and the electrically conductive products adhered on the work piece during the discharge process. Work piece material used in the process is ZrO2-20%Al2O3. Yasuki Hattori (2010) [5] - In this method submicron holes using ultra small diameter electrodes were carried out. Here two types of electrode were used, tungsten electrode and silicon electrode. P. Koshy (2010) [6] - Fast hole electrical discharge machining is not direct due to extensive relative erosion of the tool, which serve longitudinal and shape wear. In this method concentrate on monitors the back pressure of the dielectric fluid injected through the tool and the displacement of the machine tool ram, to detect hole breakout and also hole completion, with implication on process productivity and component quality. Selvarajan (2014) [10] – To study the sparking parameters namely current (I), pulse ontime (Ton), pulse off time (Toff), spark gap and dielectric flushing pressure (P) are optimized and multi responses like material removal rate(MRR), electrode wear rate (EWR) of the MoSi2-SiC intermetallic are investigated with grey relational grade analysis. MoSi2-SiC serves as an excellent temperature oxidation-resistant material prepared using pressing techniques. L. Selvarajan (2015) [11] - The latest development in the ceramic particles are of the mechanical properties and the machinability of complex 3D shapes in spark EDM. The sparking parameters for the machining of ceramic composite Si3N4-TiN are current (I), pulse on time (Ton), pulse off time (Toff) and dielectric flushing pressure (DP). Metal forming, extrusion dies, turbine blade and non-ferrous molten metal handling components are the high temperature application of the composites. The significant
parameters are measured by analysis of variance (ANOVA). Higher MRR, lower TWR, lower form tolerance and decreased orientation are verified through performing of sparking process in an effective manner. Thus in our experiment the spark EDM is used for cutting of a hexagonal shape with triangle electrode structure on SS 307 with the tool Cu electrode which used to mainly describe about the material removal rate of the spark EDM machining.

1.3. RESEARCH PLAN

1.4. EDM PRINCIPLE AND SET UP OF DRILING MACHINE:

In Electrical Discharge Machining, metal is removed by producing powerful electric spark discharge between the tool copper electrode and work piece SS 307. This principle is followed in this process. The following figure 4.1.1 shows the layout of electrical discharge machining. The main component are the electric power supply, dielectric medium, work piece, tool and a servo control mechanism.

![Figure 1 EDM drilling machine](image)

4.2.1 EXPERIMENTAL METHODOLOGY

The work piece material is shown in Figure 4.2.1. The chemical composition of SS 307 material was shown in the Table .2.
The output parameters like geometrical tolerances, material removal rate and tool wear rate are measured by CMM machine is shown in Figure 3.

1.5. FORMULA
1.5.1 MRR and TWR Formula
Measurement of Material Removal Rate:
MRR = Work piece weight loss (g)/ Machining Time (min)

Measurement of Tool Wear Rate:
TWR = Electrode weight loss (g)/ Machining Time (min)

Measurement of percentage Wear Rate:
Wear Ratio is defined as the ratio of tool wear rate to the material removal rate.
% WR= MRR/EW
1.6. RESULTS AND DISCUSSION
## 1.6.1 OUTPUT PARAMETERS ASX

<table>
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<tr>
<th>Hole</th>
<th>Electrode shape</th>
<th>Machining time (min)</th>
<th>MRR (g/min)</th>
<th>TWR (g/min)</th>
<th>Worn Ratio</th>
<th>Geometric Tolerance</th>
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**Table 1: Output Parameter Using Hexagonal Copper Electrode**
1.6.2 OUTPUT PARAMETERS WITH RESPECT TO CURRENT

1.6.2.1 MATERIAL REMOVAL RATE FIG

According to fig. 1 it clearly shows the relationship between the current and the material removal rate in EDM process. This also says that the material removal is been increased when the current is been increased in the machining process.

1.6.2.2 TOOL WEAR RATE FIG

As the material removal depends on the increase on current the tool wear ratio also increases with increase in current. From the fig. 2 it clearly shows the tool wear rate is high as we increase current in the machining process.

1.6.2.3 WEAR RATIO FIG

Wear ratio varies linearly to the current applied to the process. The fig 3 depicts that the wear ratio linearly increased and decreases with the increase or decrease in current. As the current increases the wear ratio increases similarly as the current decreases the ratio decreases linearly.

1.6.2 OUTPUT PARAMETER WITH RESPECT TO PULSE-ON-TIME.

1.6.2.1 TOOL WEAR RATE:
The fig 4 gives the relationship between the pulse-on-time and the tool wear. Pulse-on-time is the time taken by the machine to give the electric current. It clearly shows that, if there is increase in the pulse-on-time there is slight increase in the tool wear ratio. Therefore, tool wearing is high when commencement of electric discharge is long.

1.6.2.2 Material removal rate fig:

The relationship between the material removal rate and the pulse-on-time is been clearly shown in the fig 5 which says that from the 5th hexagonal holes material removal is high which requires more amount current to be passed to remove the material.

1.6.2.3 WEAR RATIO:

The wear ratio is the ratio between the tool wear ratio to the material removal rate which gives the wearing of the tool with the removal of the tool. The fig 6 used to show the wear ratio increase with the increase in the pulse-on-time and wear ratio decreases with the decrease in the pulse-on-time.

1.6.3 Output Parameter With Respect To Pulse-Off-Time. 1.6.3.1 WEAR RATIO FIG

Fig 7 defines about the pulse-off-time Vs the wear ratio. Pulse-off-time is the time where the electric current is been stopped and its material removal and tool wear rates are been found out. From the fig at hole number 5 there is huge drop in the time so at this point the wear ratio is less.

1.6.3.2 MATERIAL REMOVAL RATE

Fig 8
Material removal rate increase with the increase in the pulse-off-time. From the fig 8 its relationship between pulse-off-time and material removal rate is been studied clearly.

1.6.3.3 TOOL WEAR RATE

From the fig 9 tool wearing is been noted the pulse-off-time has the minimum effect in the tool wear rate. The tool wearing is high if the timing for the electric current is been cut off after a long time. As the cutoff of current is been made quickly it gives less tool wear rate.

1.6.4.1 GEOMETRICAL TOLERANCES WITH RESPECT TO CURRENT.

The geometric properties in a hexagon are mainly the parallelism which means the sides of the hexagon must be parallel to a regular hexagon shape. Fig 10 show the formation of parallelism with the effect of the current.

1.6.4.2 GEOMETRICAL TOLERANCES WITH RESPECT TO PULSE-ON-TIME

Fig 11 depicts the parallelism property when comparing with the pulse-on-time. The parallelism is been formed in 4 steps since a hexagon needs four parallel like to make a complete and a regular hexagonal shape.

1.6.4.3 GEOMETRICAL TOLERANCE WITH RESPECT TO PULSE-OFF-TIME
Fig 12 indicates the parallelism property with the help of the pulse-off-time. This type of parallel lines are been formed when the pulse-off-time is at less time.

1.7 CONCLUSIONS

The three main significant factors affecting the value of the MRR are the current (Ip), pulse on time and the pulse off time. From results, MRR increases with increasing current (Ip), pulse on time (μs) and decrease of pulse off time (μs). MRR increasing with increases pulse off time up to 6 μs then it’s tends to decreases.

The three main significant factors affecting the value of the EWR are the current (Ip), pulse on time and the pulse off time. Form results, EWR has been decreases with decrease current (Ip), dielectical pressure (kg/cm²). The value of EWR decreases with decrease of pulse on time. However, EWR decreases with increase the pulse off time up to 6 μs.

The two main significant factors affecting the geometric tolerance of parallelism are the current (Ip), dielectical pressure (kg/cm²). Form results, parallelism has been minimum with increase of current (Ip), decrease of dielectical pressure (kg/cm²).

From the results of response table and response graph, the optimal level setting of four machining parameters is A, B, C and D for minimizing the Electrode wear rate and maximizing material removal rate among the 9 experiments by using the Taguchi L9 orthogonal array.

The most significant factors affecting the MRR and EWR of the high-speed EDM process have been identified as factor A (Current), factor B (pulse on time), factor c (pulse off time), and factor D (dialectical pressure).

REFERENCES


